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THE
Tea Research Institute
OF
Ceylon.

IMPERIAL BUL
8 AUG. 1928
OF MYCOLOG

BULLETIN No. 2.

Annual Report for the Year 1927.



Published by
THE TEA RESEARCH INSTITUTE OF CEYLON,
VICTORIA GOMMEMORATION BUILDINGS, KANDY.

THE TEA RESEARCH INSTITUTE.

BOARD OF CONTROL.

Chairman:—Mr. R. G. Coombe.

The Hon'ble the Colonial Treasurer.

The Hon'ble the Director of Agriculture.

The Chairman, Planters' Association of Ceylon.

The Chairman, Ceylon Estates Proprietary Association.

Mr. D. S. Cameron.

Mr. J. D. Finch Noyes.

Mr. J. Horsfall.

Col. T. G. Jayawardena.

Mr. P. A. Keiller.

The Hon'ble Mr. J. W. Oldfield.

Mr. T. B. Panabokke.

Headquarters of the Board :

Victoria Commemoration Buildings, Kandy.

SCIENTIFIC STAFF.

Director :—T. Petch, B.A., B.Sc.

C. H. Gadd, D.Sc.	..	Mycologist.
T. Eden, M.Sc., A.I.C.	..	Agricultural Chemist.
D. I. Evans, B.Sc., Ph. D.	..	Biochemist.
S. Stuart Light, A.R.C.S., D.I.C.	..	Entomologist.

Laboratories :

The Tea Research Institute, Nuwara Eliya.

All communications concerning the scientific and advisory work of the Institute should be addressed to the Tea Research Institute, Nuwara Eliya.

REPORT

OF THE

Board of the Tea Research Institute of Ceylon

FOR 1927.

The Institute was established by Ordinance No. 12 of 1925.

Members of the Board :—On the 1st January, 1927, the Board of Management consisted of the following Members :—

Ex-Officio Members :—

1. The Director of Agriculture, (The Hon'ble Mr. F. A. Stockdale).
2. The Colonial Treasurer, (The Hon'ble Mr. W. E. Wait).
3. The Chairman, P.A. of Ceylon, (Mr. Geo. Brown).
4. The Chairman, C.E.P.A. (Mr. W. Coombe).

Nominated Members :—

- | | | | | | | | | | | | |
|---|--|---|-----------------------------------|---|---|---|--|---|--|---|---|
| <ol style="list-style-type: none"> 5. Mr. R. G. Coombe 6. Mr. D. S. Cameron 7. Mr. M. L. Wilkins 8. The Hon'ble Mr. J. W. Oldfield 9. Mr. J. D. Finch Noyes 10. Mr. H. Hopwood 11. Col. T. G. Jayawardene 12. The Hon'ble Mr. T. B. Panabokke | <table border="0"> <tr> <td style="font-size: 3em; vertical-align: middle;">}</td> <td>On leave, Mr. J. Horsfall acting.</td> </tr> <tr> <td style="font-size: 3em; vertical-align: middle;">}</td> <td>Nominated by the Planters' Association of Ceylon.</td> </tr> <tr> <td style="font-size: 3em; vertical-align: middle;">}</td> <td>Nominated by the Ceylon Estates Proprietary Association.</td> </tr> <tr> <td style="font-size: 3em; vertical-align: middle;">}</td> <td>Nominated by the Low-Country Products Association.</td> </tr> <tr> <td style="font-size: 3em; vertical-align: middle;">}</td> <td>Nominated by H. E. the Governor to represent small-holders.</td> </tr> </table> | } | On leave, Mr. J. Horsfall acting. | } | Nominated by the Planters' Association of Ceylon. | } | Nominated by the Ceylon Estates Proprietary Association. | } | Nominated by the Low-Country Products Association. | } | Nominated by H. E. the Governor to represent small-holders. |
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At the beginning of the year Mr. J. Horsfall was a Member of the Board having been appointed on the 26th November, 1926, to act for Mr. R. G. Coombe.

Mr. R. G. Coombe resumed his seat on the Board on the 14th April, 1927.

Mr. M. L. Wilkins resigned on the 27th January, 1927, and Mr. J. Horsfall was appointed in his place on the 14th April, 1927.

Mr. H. Hopwood, who was acting for Mr. P. A. Keiller, was relieved on the 15th June, 1927, on Mr. Keiller's return.

Mr. J. W. Oldfield resigned on the 15th June, 1927, and Mr. H. Hopwood was appointed to act for him on the 8th July, 1927.

Mr. F. E. Mackwood was appointed on the 8th July, 1927, in place of Mr. J. D. Finch Noyes, who had obtained leave of absence.

Mr. R. G. Coombe who had been elected Chairman on the 24th of November, 1926, *vice* The Hon'ble Mr. J. W. Oldfield, was absent from Ceylon on sick leave and Mr. John Horsfall acted as Chairman *pro tem*.

Meetings :—During the year the Board held 4 Meetings : 2 in Colombo and 2 in Kandy. In addition a sub-Committee met twice for the purpose of considering the question of Buildings and Laboratories.

The average attendance at Board Meetings was 8. The Director was present at all Meetings.

The Board wishes to record its thanks to the Ceylon Chamber of Commerce for the loan of the Committee Room for the Meetings held in Colombo.

Scientific Staff :—

<i>Director</i> :—Mr. T. Petch.	Commenced duties in Ceylon	8/3/26.
<i>Mycologist</i> :—Dr. C. H. Gadd	do.	1/7/26.
<i>Entomologist</i> :—Mr. S. Stuart Light	do.	17/5/26.
<i>Biochemist</i> :—Dr. D. I. Evans	do.	6/9/26.
<i>Agricultural Chemist</i> :—Mr. T. Eden	do.	18/10/27.

Laboratories :—Throughout the year the Scientific Staff has occupied temporary quarters at Lindfield, Nuwara Eliya.

Experiment Station :—During 1926, 18 estates were considered, and during 1927 the number was 20. Most of these proved, on preliminary inspection, to be unsuitable on account of steepness, inaccessibility, excessive rainfall, insufficient water supply or other cause. In a few cases negotiations were commenced, but these broke down before they had been carried very far. Only three estates have been valued with a view to purchase ; negotiations with regard to two of these estates were carried on for some months before the proprietor finally decided not to sell. The matter of the other estate is still under consideration.

Finance :—The Institute holds the following investments :—

Rs. 150,000 on fixed deposit @ 4% with the Mercantile Bank of India, Ltd., Kandy.

Rs. 75,000 on fixed deposit @ 4% with the Mercantile Bank of India, Ltd., Colombo.

A Statement of Accounts and Balance Sheet are attached.

General :—The Institute published one Bulletin in 1927. A Quarterly Journal will be issued in 1928. The annual subscription for one copy of all publications issued during each year is Rs. 15. The Register of those wishing to receive these publications contains 1,026 names.

The Members of the Board again wish to stress the fact that until a suitable property has been acquired it is impossible for the Institute to carry out many of its important duties properly.

A. W. L. TURNER,
Secretary,

Tea Research Institute of Ceylon.

Kandy, 7th March, 1928.

REPORT

OF

THE DIRECTOR,

TEA RESEARCH INSTITUTE OF CEYLON,

FOR 1927.

The Institute is still in temporary quarters at Nuwara Eliya, as it has not yet been possible to acquire an estate or land suitable for a permanent Experiment Station. The Director has inspected and reported on nine estates.

Laboratory :—A Petrol Gas Plant has been erected, and three working rooms are now fitted with gas and water. A room has been fitted up for the Agricultural Chemist, and another room has been furnished with a large fume cupboard, Kjeldahl apparatus, muffle furnace, etc., for the use of both chemists jointly.

Library :—The Proefstation voor Thee, Buitenzorg, Java, has kindly presented all the available numbers of its Mededeelingen, and has placed the Institute on the free list of the Archief voor de Theecultuur; and the Algemeen Landbouw Syndicate, Java, has similarly favoured the Institute as regards their official Journal, De Bergcultures.

From the United Planters' Association of Southern India, we have received the Administration Report, and other publications, of the Tea Scientific Officer.

Welcome gifts have been received from Mr. S. O. Hanbury, a former Ceylon Planter, who has presented the Tea Cyclopaedia (1881) and other books, and from Mr. R. F. Christie, who has given six early volumes of the Tropical Agriculturist, viz. I-III and V-VII. As announced in the report for 1926, the Institute would be grateful for any copies of old books and pamphlets relating to tea, for which their owners have no further use, especially any volumes of the Tropical Agriculturist up to vol. XXIV, Circulars of the Royal Botanic Gardens, Peradeniya, Annals of the Royal Botanic Gardens, Peradeniya, Bulletins 45 and 52 of the Department of Agriculture, Ceylon, Bulletins 1-3, 5-8, 10, 13, 15, 16 18, 20, 22, 24, 31, 33-35, 39 of the Indian Tea Association.

Staff.

Mr. T. Eden, M.Sc. (Manc.), A.I.C., war service, 1916-1919, formerly Assistant Chemist (1921-23), and (1923-27) Ecologist in charge of Field Experiments, Rothamsted Experimental Station, has been appointed

Agricultural Chemist and arrived in Ceylon on October 17th. Since his arrival, Mr. Eden has visited estates to gain acquaintance with Ceylon conditions, and has spent some time at Peradeniya to ascertain what is being done by the Department of Agriculture in chemical research and field experiment. Preliminary field experiments have been planned, and negotiations for carrying out these on an estate are in progress.

Work of the Staff.

The correspondence passing through the Director's hands during the year comprised 2,027 letters in and 1,267 letters out.

Addresses on the work of the Institute were given by the Director to the Alagalla, Rangalla, and Kelani Valley Planters' Associations.

Owing to a severe outbreak of the *Cercospora* leaf disease, the question was raised whether it was not advisable to restrict the planting of *Acacia decurrens* in estate fuel blocks adjacent to tea. On the initiative of the Institute, this question was referred by the Planters' Association of Ceylon to the District Planters' Associations interested in *Acacia decurrens* as a green manure or a fuel tree. As would be expected, the opinions expressed varied with the district's experience of the *Cercospora* disease. Roughly, the districts on the west of the hills, where the rains of the South-west monsoon fall and the *Cercospora* disease is serious, were in favour of some restriction. Even in the same district, the planters at one end, where the disease occurs annually, favoured restriction, while those at the other end, where the estates do not yet suffer, were opposed. Practically, the replies from the District Associations reflected the distribution of the disease.

At the request of the Institute, the matter was referred to the Conservator of Forests to ascertain the policy of his Department in the re-forestation of estate fuel blocks. His report was as follows :—

No. M. 5609.

Office of the Conservator of Forests,
Kandy, September 15th, 1927.

Sir,

* * * * *

2. As far as my Department is concerned it is not likely that pure plantations of *Acacia decurrens* will be required in the future, unless for the special purpose of growing wattle bark, for which at present there appears to be insufficient land available. If this project is pursued, however, it would be located in the dry region of the Province of Uva, in which, I believe, the presence of *Cercospora Theae* is not found, or at any rate the disease is not virulent.

3. In other cases, *Acacia decurrens* is required to some extent as an understorey in fuel plantations of Eucalyptus, for purposes of preserving soil fertility, but whereas this formation is in practice in the region of Ohiya in the Province of Uva, the species is excluded from future operations in our planting programme from Kandapola to Ambawela and Pattipola.

4. At present we have the following areas in which *Acacia decurrens* occurs :—

Kandapola	221	acres mixed with other species.
Conical Hill	120	do do.
Pattipola	117	do do.
Ambawela	24	do do.

The species is not being replaced in future clearings.

5. Under the estate fuel blocks scheme there are 102 acres containing *Acacia decurrens* in the vicinity of Nuwara Eliya, Kandapola, Ragala, Mahacoodagala, Gonapitiya, Ramboda, Nanu Oya, and Agrapatnas, but no planting with this species has been done since 1922, and it will not be put down in future.

6. Unless therefore a scheme for growing wattle bark materializes, the Department is not greatly affected by the proposals, except in the Ohiya region, which, I understand, is not objected to, but as it may, in Forestry, be found necessary later to maintain a suitable admixture of *Acacia decurrens* with other species, especially gums, I should deprecate any sudden measure to restrict the growth of this useful, soil improving species, until research has definitely exhausted other causes of *Cercospora* infection.

The Secretary,	I am, Sir,
Planters' Association of Ceylon,	Your obedient Servant,
Victoria Commemoration Buildings,	J. D. SARGENT,
Nos. 40 and 41, Ward Street, Kandy.	Conservator of Forests.

It has been suggested that it is superfluous to restrict the planting of *Acacia decurrens*, when it is not the only tree which may spread the disease. The answer to that is that at the present time it is undoubtedly the chief source of infection to tea.

Cercospora Theae was first found on tea in a tea nursery in Pundaluoya in 1909. It had not been recorded previously from any other country, and was described as a new fungus, that is, a hitherto unknown species, from the Ceylon specimens. In such circumstances, it must be regarded as an indigenous fungus, which originally occurred on some jungle plant before it attacked tea. Consequently, it is quite safe to say that other trees than *Acacia decurrens* may harbour this fungus.

It was not, however, until about ten years after its original discovery that the disease began to make its presence apparent on old tea. By that time, *Acacia decurrens* had been planted widely through tea above an elevation of 4,000 ft. Examination of the affected fields showed immediately that, in addition the normal method of distribution by spores, the disease was communicated to the tea by the falling *Acacia* leaflets, which, being small, could be carried by the wind and readily adhered to the tea leaf when wet. It is impossible to doubt that the spread of *Cercospora* to tea was favoured by interplanting *Acacia*.

That other sources of *Cercospora* infection exist, no mycologist would dream of denying. Obviously there is the original source of infection somewhere. But, as a general rule, when a fungus which is parasitic on a jungle plant passes over to a plant cultivated on a large scale, the jungle becomes of minor importance as a further source of the disease. That happened in the case of the coffee leaf disease.

The fact that *Cercospora* can attack *Eucalyptus* spp. was made evident about the year 1919 when the Government plantations of Karri, etc., at Nanuoya, which were interplanted with *Acacia decurrens*, were severely attacked and a large proportion of the young plants, both *Eucalyptus* and *Acacia*, were killed out. The disease is known to attack Red Gum, but, in general, it does not cause defoliation of gums, and, if it should, the danger of its distribution by means of falling gum leaves is much less than is the case with *Acacia* leaflets.

Cercospora leaf disease of tea has been recorded from India, but judging from the reports on the progress of the disease in the field it would appear doubtful whether it is the same as the Ceylon disease.

Tea Tortrix has been the subject of much discussion during the year. In February a questionnaire was issued to all tea estates in the principal tea districts, in order to ascertain the distribution of the pest and to what extent measures were being taken to combat it. The response was not entirely satisfactory, only about two-thirds of the circulars being returned. These, however, were sufficient to show that the voluntary agreement arrived at in 1924 by the districts mainly affected had proved a failure. In the districts in question, egg-masses were collected on only forty-three estates in 1925 and fifty-nine estates in 1926.

Subsequently the question of the control of Tea Tortrix was raised by the Planters' Association, and the Director of the Institute was requested to state his views at the meeting of that Association in July. It was resolved at the meeting to recommend to Government that Tea Tortrix should be proclaimed a pest under the Plant Protection Ordinance, and that recommendation was endorsed by the Estates Products Committee of the Board of Agriculture. Tea Tortrix was proclaimed a pest on November 11th, 1927.

In 1927, Tea Tortrix spread to Uda Pussellawa.

Towards the end of the year, serious outbreaks of Tortrix occurred in nearly all the Tortrix districts, including many which had hitherto been only lightly attacked, and the general opinion is that 1927 has seen the worst attacks of the pest that have yet been known.

Enquiries have been made of other countries to ascertain whether any parasite existed in any other part of the world which might be introduced into Ceylon for the control of Tortrix. Up to the present, the replies to these enquiries indicate that the only foreign egg parasite likely to be of use is one which has already been recorded as existing in Ceylon as a parasite of Tea Tortrix eggs. Attention is therefore being concentrated on the multiplication of the local parasite. This subject is dealt with in the report of the Entomologist.

On several occasions, especially at the meetings of the District Planters' Associations, it has been suggested that the Institute should publish a Quarterly Journal. This year, the Sabaragamuwa Planters' Association

passed a resolution requesting the Planters' Association to recommend to the Tea Research Board that the Institute should publish a Quarterly Journal, and this was strongly supported by the Uda Pussellawa Planters' Association. It has now been decided that the Institute shall issue a Quarterly Journal, edited by the Director of the Institute. The Journal will include original articles by the staff on their work and on matters of interest to tea planters, and, in addition, summaries and reviews of work on tea in other countries.

Negotiations are in progress for inaugurating certain preliminary field experiments, which are of fundamental importance for future work in this direction, in co-operation with estates. As previously decided, these will be carried out in the neighbourhood of Nuwara Eliya, where the weighing of the crop and other measurements can be carried out by the staff of the Institute. In this connection, it is of interest to note that Sir A. D. Hall, in an article on "The principles of agricultural experiments" (see Tropical Agriculturist, September, 1925, p. 184), laid down the rule, with regard to co-operative experiments, that "the agricultural organiser cannot ask the farmer to do the measurement work." That is the crux of the matter. If that is true of field experiments in temperate climates, where, in general, measurements and records are taken twice in the year, it is much more applicable to experiments on tea, where records must be taken every ten days or so. That has been fully demonstrated in the past in Ceylon, and it is a waste of time and effort to begin co-operative experiments merely for the sake of "doing something," when experience has shown that experiments without scientific control of the measurements can have no definite results.

The thanks of the Institute are tendered to the Managers and Superintendents of Scrubs Estate, Pedro Estate, Delmar Estate, and Caledonia Estate for the supply of material and the provision of facilities for experiment; to Messrs. Keell and Waldock for testing samples of tea; to Messrs. Cargills Ltd., the Colombo Commercial Co., and Gordon Skene & Co. for materials for experiments; and to the Director, Colombo Museum, the Government Analytical Chemist, the Biological Department, University College, and the Department of Agriculture, for the loan of literature.

Reports of the Scientific Officers are appended.

T. PETCH,

Director,

Tea Research Institute.

REPORT OF THE MYCOLOGIST.

Advisory:—Five hundred and forty-nine letters have been received and four hundred and eighteen despatched. One hundred and ninety-four consignments of diseased plants have been received for examination and report. Of these, one hundred and sixty-five were tea; the remainder consisted of *Acacia*, *Albizzia lophantha*, *Albizzia moluccana*, dadap, *Eucalyptus*, *Grevillea*, lupin, *Indigofera* and *Tephrosia*. Of the tea consignments 63 were root diseases, 29 stem diseases, 31 leaf diseases, 32 seedling diseases and 10 miscellaneous.

Visits have been made to 40 estates in the Agrapatana, Ambawela, Bogawantalawa, Dickoya, Dimbula, Galaha, Gampola, Hatton, Haputale, Hewaheta, Kalutara, Kandy, Koslande, Lindula, Maskeliya, Nanuoya, Nivitigalla, Norwood, Pundaluoya, Rakwana, Udapussellawa, Wategama and Welimada districts.

Agricultural Conference:—At the Agricultural Conference at Peradeniya on March 9th, I read a paper entitled "Some diseases of the Tea Bush." This contribution was published in the daily press and the Tropical Agriculturist for April.

In the course of an address on "Recent work on root disease of economic and other plants in Ceylon," the Government Mycologist expressed the opinion that *Rhizoctonia bataticola* is the only parasite of present importance in the causation of root disease. I opposed this view at the conference, and later wrote a fuller criticism which was published in the daily press and the Tropical Agriculturist for June, 1927.

Experimental evidence having a bearing on this controversy is referred to in this report under the heading "Seedling Diseases."

P.A. Meetings:—By invitation I attended the meeting of the Sabaragamuwa P.A. on May 28th and gave an address on "Wood-rot or branch canker of tea." An interesting discussion followed. The address was published in the daily press.

I also attended a meeting of the Dimbula P.A. on September 2nd, and contributed to the discussions on *Cercospora* leaf disease and Shot-hole Borer.

TEA.

Root Diseases.

Poria:—The root disease caused by *Poria hypolateritia* is probably the most serious root disease found on tea estates at the present time. On many estates, the loss of bushes from this cause is very great, and many large bare patches, the result of the activities of this fungus, are to be seen. Despite careful treatment, many of the infected areas are becoming larger annually owing to further losses at the perimeter.

The failure to stop the steady progress of this disease is due mainly to the fact that it is not generally realised that bushes may be seriously infected without exhibiting any symptom above ground that anything is amiss. The bushes adjoining a dead bush are, in the majority of cases, already infected by the time the dead bush is dug out. If these infected but apparently healthy bushes are left, they ultimately die and the fungus passes to the roots of adjoining bushes. In this way, treatment may follow the disease without overtaking it.

Trenches are usually constructed to stop the advance of the fungus. If suitably placed, dug to a sufficient depth and kept open, they usually prove satisfactory. But, where dead and moribund bushes only are dug out, the fungus is, as it were, chased as far as the trench, where with good luck it is cornered. This process may take several years, during which time dead bushes have to be removed periodically.

The disease can be eradicated from an area only by the removal of all roots bearing the pathogenic fungus. If this is to be achieved, all infected bushes must be destroyed even though they may appear quite healthy when judged by their aerial parts. It is not an easy matter to examine the roots of a bush *in situ* in order to ascertain whether any roots are infected. Infected roots are liable to be overlooked, in which case further treatment will have to be carried out later on that area. For this reason, it seems preferable, when dead bushes are being dug out, to remove apparently healthy bushes also from the perimeter of the infected area, without preliminary examination. This ensures the removal of practically all infected roots and renders possible the eradication of the fungus before it reaches the guard trench.

Brown Root Disease and Ustulina :—Where the Brown root fungus and Ustulina occur on the roots of tea, their origin can usually be traced to old jungle stumps. The practice of removing old stumps from tea fields has resulted in a marked diminution of these diseases.

Diplodia Disease :—The Diplodia disease is probably the most prevalent root disease at mid and low elevations. There appears to be a close relationship between the periods between pluckings and prunings and the incidence of this disease. The smaller the interval between plucking rounds the greater is the incidence of Diplodia.

The periods between pluckings and between prunings are governed to a large extent by climatic conditions and their resultant effect on growth. Growth demands an elaborated food supply (as distinct from the presence of suitable fertilisers in the soil). The greater the growth (*i.e.* flush, which is removed as crop) the greater is the amount of elaborated food consumed by the bush. Consequently, other things being equal, the smaller is the amount of food available for storage as reserve.

After pruning, when the bushes are bare of leaf, all new growth is dependent upon reserves stored within the bush. Bushes with little or no reserves can make little or no growth. The failure to recover from pruning constitutes the primary symptom of what is commonly known as the Diplodia root disease. The organisms found on bushes affected by this disease may be of a secondary nature, *i.e.*, they may invade the roots after the latter have become moribund owing to the absence of a suitable food supply.

Investigations into the connection between food reserves and the incidence of this disease so far have provided interesting results, which suggest that this line of research should be continued. At present, the theory expressed here must be regarded purely as a tentative explanation. Reference is made to it partly because it forms a part of the results of the year's work, and partly, to draw attention to the possible necessity, in areas where this disease is prevalent, of a lighter form of pruning or/and a nursing of the bushes' resources before pruning. Where this disease occurs severely after every pruning despite careful treatment, the questions of plucking and pruning may be worthy of careful consideration and experimentation.

Armillaria :—A root disease of tea probably caused by *Armillaria* sp., (possibly *A. mellea* or *A. fuscipes*) has been reported for the first time in

Ceylon this year. It was first found on nursery plants when they were being lifted for transplanting. Later, and in another district, the same disease was found on mature tea.

The nursery plants appeared quite healthy while in the beds, but when pulled from the ground, the tap roots were found to be split from the tip to the collar as though with a knife (See Fig. 1). Sheets of white fungus were present on the split surfaces, and it was apparent that this fungus was the primary cause of the root-splitting. In exceptional cases, the root splits along more than one plane. An example of this form of injury is shown in Fig. 2. Here, splitting had occurred along three planes converging towards the distal end of the root.

Fragments of rhizomorphs, identical in structure with those described for *Armillaria mellea*, were found attached to a diseased root. The rhizomorphs appeared to rise from the fungus covering the split surface of the roots. In pure culture, the white mycelium from the split surface of the roots gave rise to definite rhizomorphic strands. This observation supports the view that the mycelium which caused the root-splitting and the *Armillaria*-like rhizomorphs belong to the same fungus.

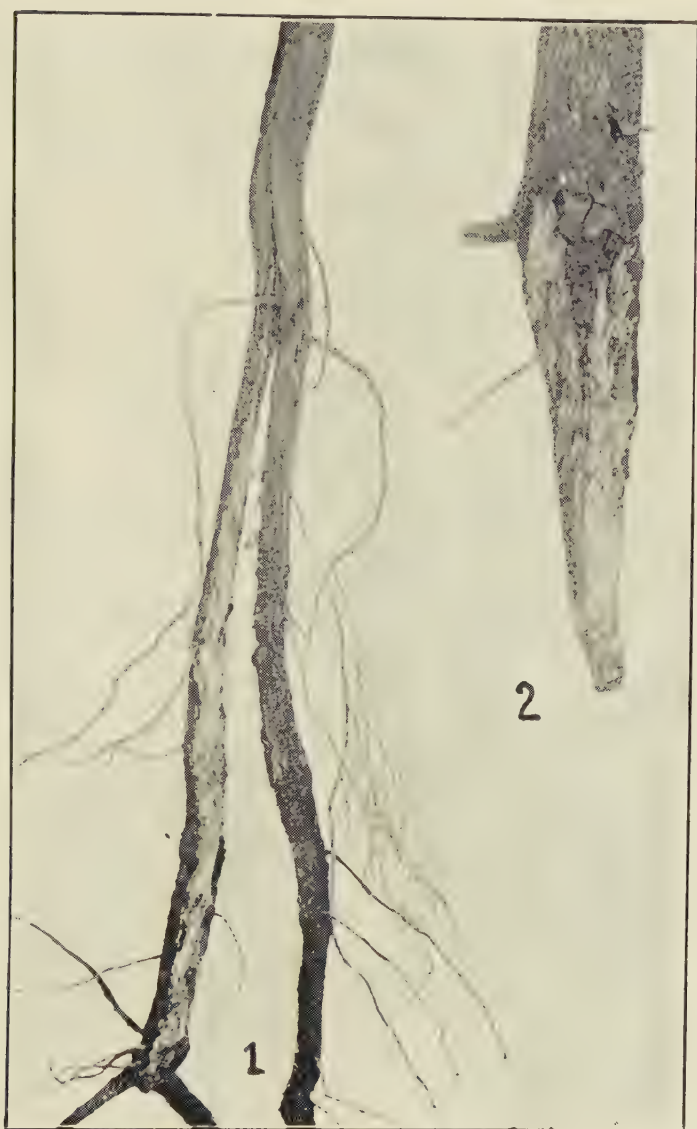
On mature tea the symptoms were different. Deep cracks occurred on the infected roots and at the collar. The cortex was permeated with thick cords of fungus mycelium, internally white, and with a dark red, almost black, external surface. The characteristic rhizomorphs were found attached to the cortex and running free through the soil.

At present, only one mature bush attacked by this fungus has been seen. The symptoms, however, agree very closely with those described for *Armillaria mellea* on tea and other trees elsewhere. No fructifications have yet been found. There can be little doubt, however, that the fungus in question is the ubiquitous *Armillaria mellea* or the closely allied species, *A. fuscipes*, described from Ceylon.

The parasitism of *Armillaria mellea* has been well proved elsewhere. This fungus can gain entry into uninjured root tissues, and it almost invariably originates from old stumps. Its presence in Ceylon affords a further reason for the continuance of the practice of removing old stumps from tea estates.

Lime in the treatment of Tea Root Diseases:—The benefit derived from the use of lime in the treatment of tea root diseases caused by *Poria*, *Rosellinia*, *Ustulina* and the Brown root fungus does not appear to warrant its continuance. It is very doubtful that lime has any detrimental effect on these fungi. On some soils it is possible that for tea cultivation the lime may have a definite detrimental effect on the soil reaction. For these reasons it appears advisable to eliminate lime from the general routine treatment of tea root diseases.

As regards the *Diplodia* root disease there is a very definite opinion concerning the value of lime. It has been stated "As practical planters we consider that if we apply a big dose of lime to a tea bush partially affected with *Diplodia* we can in 50 per cent. of the cases cure that bush." Unfortunately, at present we have no data concerning the percentage of the partially affected bushes which would recover if lime were not added to the soil. Definite experimental data of this description from infected fields would be of great value.



TEA ROOT ATTACKED BY ARMILLARIA.

A few determinations of the reaction of soils from infected fields and neighbouring healthy tea have been made. From these it would appear that there is no connection between the incidence of *Diplodia* root disease and soil reaction. Whatever beneficial effect lime may have on this disease is probably not exerted through the medium of soil acidity.

It would appear advisable, for the present, to continue the use of lime in the treatment of this particular root disease (*Diplodia*) until further investigations have been made into its causation and the value of lime in its treatment.

Stem Diseases.

Pink Disease (*Corticium salmonicolor*):—Pink disease has been found on a few estates adjoining jungle. When the period between prunings is three years or less the disease does little damage and is rarely seen. But when the pruning cycle is increased to four years, the disease makes its presence known by the occurrence of dead branches bearing the characteristic pink-coloured fructification of this fungus. A reduction of the pruning cycle is likely to prove the most efficient means of control of this disease on tea in plucking.

The satisfactory treatment of seed bearers affected by Pink disease is a much more difficult matter. The disease was seen on a few trees which had been allowed to grow up as seed bearers. The trees were situated close to jungle from which infection appears to have occurred. It is very doubtful that trees in such a situation will ever become efficient seed bearers.

Wood-rot or Branch Canker :—Experiments to test the relative values of different types of antiseptic wound dressings on tea have been started on two estates, one in the Udupussellawa district and the other in Lindula. Field observations indicate quite clearly that wood-rot or branch canker almost invariably starts at pruning cuts. Large cuts offer better facilities for the entry of fungi which cause this condition than do cuts on branches of smaller diameter. Consequently, it appears necessary that if wood-rot is to be avoided, the large wounds made during pruning should be protected by an artificial antiseptic cover until such time as the wound is completely healed.

The provision of an artificial protective cover for wounds must not be confused with the problem of speeding up the healing process. The natural method of healing wounds is by the formation of a layer of live tissue (callus) over the exposed wood, such that the latter is entirely covered. This callus tissue grows inwards from the live cells at the perimeter of the wound. The healing of tea wounds in this way is normally very slow in Ceylon, probably because such great demands are made on the bush's food reserve as a result of plucking and pruning. Any treatment which will increase the rate of healing must be beneficial, but this problem, at present, is quite distinct from the provision of a suitable artificial cover to preserve the exposed wood during the interval between wounding and complete healing.

Natural healing is a process of growth, and consequently it is likely to be stimulated by the provision of an abundant food supply. The provision of a suitable food supply implies more than a liberal manuring pro-

gramme. The raw materials obtained from the soil and collected from the atmosphere have to be elaborated to form carbohydrates, proteins, etc., before they can be regarded as true food. The manufacture of food from the raw materials is carried on mainly in the leaf. The new leaves formed for the purpose of carrying on this manufacture, however, are removed from the tea bush as crop. Plucking acts as a stimulus for the production of new shoots, the formation of which also makes large demands on the reserve of manufactured food. At pruning time the bush, as a rule, is completely denuded of leaves. As already stated in connection with Diplodia root disease, new growth after pruning is entirely dependent upon the reserves of elaborated food stored away in the bush. There is therefore a constant demand by the tea bush for elaborated foods. Consequently, the amount available for the healing of wounds is dependent upon such factors as the plucking and pruning methods, climatic conditions, etc., as well as upon the amount and value of the manures applied.

Antiseptic treatment of the pruning cuts will not supply food material which can be used to accelerate the healing process. On the other hand, the antiseptics may actually delay it, if they have any detrimental effect on the active live cells which give rise to the callus. The most useful dressing is one which gives maximum protection against wood-rot with a minimum detrimental effect on the live cells.

The number of substances which might be tried as wound dressings is very large. The aim of a preliminary experiment must be to determine the type of dressing rather than the particular substance for the purpose. With this object in view the following substances are being tried out on saw cuts in the districts already mentioned: Ordinary gas tar, washed gas tar, tar and wax, red oxide paint, white lead paint, Cargilineum A, Cargilineum B, copper sulphate and bichromate solution, Burgundy paste and grafting wax.

The Cargilineum mixtures, which are greasy in nature, the Burgundy paste, and the copper sulphate and bichromate solution were, to a greater or less extent, washed off by rain three months after application. It remains to be seen whether sufficient antiseptic material from these dressings has been left in the wood to serve the purpose in view. The tars and paints form good covers which should withstand weathering. For this reason they would appear more likely to be efficient than the more easily removed dressings.

It is already evident, that 100 per cent. efficiency is not to be expected of any antiseptic cover placed on large cuts. The reason is that it is impossible, when the cut is made, to state at what point the new shoots will arise. Sometimes the new shoots arise very near to the cut, but in other cases they may develop four inches or more below the cut. In the latter cases it is highly probable that the stem above the uppermost new shoot will ultimately die back, and this mass of tissue which is protected only on the upper surface will afford suitable places for the entry of wood-rotting fungi.

The treatment of already cankered bushes is in many cases a very difficult matter. The removal of all the badly cankered branches would leave many bushes with little or no frame on which to build. In such cases collar-pruning appears to be the most feasible method of treatment. It

appears better to attempt to build a sound frame on a healthy root system than to attempt to build it on an already rotten foundation. One estate which has experienced a considerable diminution of crop mainly due to the ravages of this disease, has undertaken a somewhat extensive collar-pruning programme. Bushes with very badly rotted frames have been collar pruned ; in some fields practically every bush has had to be so treated. The results at present are very encouraging ; the new wood is sound and vigorous, and there is a marked increase in yield from the treated fields.

Collar-pruning is not advocated as a general method for the improvement of yield ; it should be avoided wherever possible. But it appears to be the only practicable method of treating certain badly cankered bushes. With such bushes it is well worth a trial. The cut should be made at or just below ground level, and covered with earth after the smoothed surface has been treated with tar or other similar cover. Every care should be taken with the new wood to prevent the entry of wood-rotting organisms after pruning, and so preserve the new frame.

Wood-rot, as a rule, does not result in the sudden death of a tea bush. A bush may be badly cankered at the crown without causing any serious diminution of crop. Two very virulent types have, however, been observed. One is apparently caused by *Ustulina zonata*, which is well-known as the cause of a root disease, and the other is usually associated with *Aglaospora aculeata*, which has been described as a stem disease. In both cases infection occurs at the crown ; a wood-rot starts and progresses rapidly down the main stem and into the root system. Investigations made in the field indicate clearly that in such cases infection has occurred above ground, and that the deaths are a direct result of the rotting of the woody parts of the bush. These observations lend support to the view that wood-rot or branch canker of tea is not caused solely by one fungus, and that the type of rot will vary to some extent with the different species which cause it.

Dieback :—A dieback of shoots occurred on an estate in the Agrapatana district in the early part of the year. In advanced cases the shoots were ringed at the base and exhibited the type of injury which is usually ascribed to the effect of strong winds. In this instance, however, it appeared doubtful whether the injuries were caused by the wind. Pure cultures of *Leptothyrium Theae* Petch were obtained from the diseased stems, but inoculation experiments demonstrated that this fungus is but a weak parasite. Positive results were obtained only when the shoots were wounded as by plucking. It appeared very doubtful that the activities of this fungus alone would account for all the symptoms observed in the field.

Leaf Diseases.

Brown Blight :—Brown Blight (*Colletotrichum Camelliae*) is one of the commonest diseases of the tea bush. Though present on most estates it occurs, as a rule, in negligible quantity on the older leaves and causes so little damage that it is of little economic importance. At times it becomes more prevalent and attacks the younger leaves. Then it demands more serious consideration.

This disease came into prominence during the early months of the year, particularly March, when reports were received from most districts regarding its rapid increase. The attack decreased in April and little was heard or seen of it during the later months.

The rainfall during the early months of this year was greatly in excess of the general average for these months. The abnormal weather of February and March provided optimum conditions of temperature and moisture for the fungus, and resulted in an increased incidence of Brown Blight. Petch has recorded that a spell of wet weather during the dry season appears to produce conditions highly favourable to this disease. This year's attack, therefore, is in accord with previous observations.

Cercospora Theae :—Severe attacks of the *Cercospora* leaf disease were experienced on many estates during the south-west monsoon. The bushes in some fields were entirely defoliated. In the majority of cases investigated, the disease could be traced definitely to the presence of *Acacia decurrens* interplanted with the tea. The Acacias were defoliated and the fallen leaflets conveyed the disease to the tea. In one case the disease appears to have been carried from gums grown as wind breaks.

Cercospora spores can rarely be found on infected tea leaves, but they are produced in abundance on Acacias, gums, and *Albizia lophantha*.

For this reason one must conclude that infection passes from Acacias and other spore-bearing hosts to tea, and rarely from tea to tea. The spore, however, is not the only medium by which the fungus is dispersed. Infected leaves which fall from attacked plants are carried by wind for distances varying with the size of the leaves. The leaves of *Acacia decurrens* are very small and can be carried considerable distances by the wind. Moreover, the leaflets adhere readily to the tea leaf; thus, opportunity is afforded for the fungus to pass from the *Acacia* leaflets to the tea. Under certain conditions this is probably the commoner mode of infection, though spore infections undoubtedly occur under very moist conditions.

The principle factor affecting the occurrence of the *Cercospora* leaf disease is the humidity of the atmosphere. The prevalence of mist is of more importance than the amount of rainfall. It was particularly noticeable that the degree of attack varies with the amount and duration of the mists. The higher fields which were enveloped by mist for long periods were the most seriously attacked, the tea bushes being more or less completely defoliated. Fields below the mist zone were less seriously affected; the bushes were not defoliated, though characteristic spots on the young leaf demonstrated the presence of the fungus.

The occurrence of this disease on tea in Ceylon is no indication that the bushes are weak and lacking in vigour. Healthy, vigorous, well-cultivated bushes are liable to severe attack. Such bushes, however, make a rapid recovery when climatic conditions improve.

Since the control of weather conditions is out of the question and the use of fungicides to prevent this disease is impracticable, attention has to be paid to the presence of trees, like *Acacia decurrens*, which harbour the fungus *Cercospora*. Whether such trees should be cut out from fields liable to this disease depends upon the circumstances of each individual case. The point to be decided is whether the benefit derived from them is greater than the loss resulting from the damage done to the tea by the disease. If the disease is to occur annually in such severity as has been experienced this year, the question of the removal of trees which harbour *Cercospora* will have to be seriously considered.

Searches have been made in the field for the fructifications referred to in my previous report but so far without success.

Coniothyrium Theae :—The fungus *Coniothyrium Theae* Petch was found in association with a disease of tea leaves sent to the laboratory for examination. This fungus has not previously been recorded as the cause of a leaf disease of tea. An examination in the field disclosed the fact that the affected bushes exhibited symptoms of the Witches' Broom disease also. The leaf disease had to be regarded as of secondary importance, because neighbouring bushes unaffected by Witches' Broom were free from the leaf disease. It is to be expected that bushes affected by the Witches' Broom disease, owing to their weakened condition, will fall victims to fungi like *Coniothyrium Theae* which normally do little or no harm.

Seedling Diseases.

Rosellinia :—The majority of the fungi which cause root diseases of mature tea appear to be incapable of attacking seedlings. *Poria*, *Ustilina*, and *Fomes lamproensis* (Brown root disease) though common on mature tea, have not yet been recorded on seedlings. This suggests that seedlings are immune to these fungi until they have reached a suitable stage of development.

Rosellinia arcuata was recorded for the first time, this year, as the causative agent of a root disease of tea seedlings in Ceylon. The seedlings were attacked at the collar and the characteristic mycelium was abundant in this region. The damage caused by this fungus in a nursery can be very great, owing to the close proximity of the plants and to the fact that the fungus spreads rapidly over the surface of the soil from one plant to the next.

In order to test the pathogenicity of *Rosellinia arcuata*, healthy tea seedlings were inoculated with fragments of infected roots and with pure culture in the laboratory. Care was taken to prevent injury to the seedlings when the inoculum was being introduced into soil. In every case the seedlings died about two months after inoculation, although the control plants remained vigorous and healthy. In one experiment four control seedlings were grown in the same pot with the inoculated plant; in other experiments the control plants were grown in separate pots though in similar soil.

The fungus gained entrance into the seedlings *via* the tissues at the collar. No doubt this was due partly to the fact that the infectious material was placed near the collar. It demonstrates, however, that a pathogenic soil fungus can easily gain entrance into its host by other ways than *via* the fine rootlets.

In view of the statement that *Rosellinia*, amongst other fungi, is only of secondary importance in the causation of root disease, careful examination of seedlings which died after inoculation was made for the presence of *Rhizoctonia bataticola*. In no case was any trace of this fungus found, nor did it occur in any culture inoculated with portions of the dead roots. The evidence is entirely against *Rh. bataticola* being concerning in any way with the deaths of these seedlings, before or after inoculation with *Rosellinia arcuata*.

The experiments prove conclusively that *Rosellinia arcuata* is a virulent parasite and can attack healthy tea plants which have not been weakened previously by adverse environmental conditions or by the attacks of other fungi.

“Bitten Off” Disease :—The commonest disease of tea seedlings is that known as “Bitten Off.” Seedlings affected by this disease are unthrifty and when dug out of the soil, the roots are found to be decayed. Commonly, all the laterals have disappeared and a rot is seen to be progressing up the tap root. If the plants are pulled from the beds, the root system has the appearance of having been bitten off owing to the decayed parts being left in the soil.

As yet, it has not been possible to reproduce these symptoms by inoculating healthy plants with fungi isolated from diseased specimens. For this reason it seems possible that some adverse condition of the soil is necessary before the rotting of the root can be started.

The disease occurs on soils of different reactions, and there is no evidence to indicate that the disease is associated with soils of particular degrees of acidity. If the soil is insufficiently acid, pathological symptoms may be induced, but they are not usually the symptoms of “Bitten off” disease.

Experiments designed to determine the effect of soil moisture indicated clearly that an excess of soil water induces a rot of the roots similar to that known as the “bitten off” disease. Consequently, the provision of good drainage is of the utmost importance when laying out tea nurseries. The disease, however, has been seen in nurseries in which there is no reason to suspect that the drainage is at fault, so an excess of soil moisture cannot be regarded as the sole cause of this disease, though in some cases, it may be an important contributory factor.

Galls on Leaves :—Tea seedlings were submitted by an estate in the Kalutara district for examination. These showed peculiar blister-like swellings (galls) on the leaves which caused them to curl abnormally. The galls were generally paler in colour (sometimes yellow) than the surrounding tissues. They were oval in shape, up to 5 cm. long, and somewhat resembled a blister. These swellings resulted from a multiplication of the leaf cells in definite regions usually adjoining the mid rib. A careful microscopic examination of the tissues failed to reveal the presence of any fungus or other organism in association with them. No explanation can be given regarding their causation. The fact that the rainfall at the time was particularly heavy—over 50 inches fell during the previous month—may be of some significance.

Tea Seed.

An interesting case of delayed germination of tea seed has been under observation. A sample of seed was submitted for examination and report, as adverse reports had been received regarding its germination. The seed appeared to be fresh and in excellent condition on arrival. After seven weeks, however, only 42 per cent. had germinated. In no case was the young root more than 0.6 ins. long. After examination, the seeds were returned to the soil, the ungerminated seeds being placed in a separate pot. After 5 months, 71 per cent. of the seed had germinated and given rise to healthy plants.

Physiological.

Water Culture Experiments :—Tea seedlings have been grown in water culture solutions of different pH values to determine the effect of acidity on their growth. The most notable effect was on the root development.

The seedlings in the more acid solutions (pH 3.5 and 4.5) produced new roots. These were white, healthy and turgid. In solutions approximating neutrality (pH 6.5 and 7.5) the existing roots became brown and flaccid, and no new roots were formed. By altering the acidity of the solutions the general appearance of the root systems could be altered.

The solutions approximating neutrality also had a detrimental effect on the aerial growth. The leaves became smaller and paler in colour.

Soil Cultures :—Tea seedlings are also being grown in soils of different reactions. The alterations in soil reaction were brought about by means of sulphur and lime. These experiments are not yet completed, but it is already evident that alkaline soils and those approximating neutrality have a marked detrimental effect on the plants. The new leaves become successively smaller and paler; ultimately they may become white. The stem does not elongate normally; the leaves became crowded and in some cases the plants die.

The symptoms developed by the seedlings grown in the soils of unsuitable reaction are similar in some respects to those known on older bushes affected by what is termed the Witches' Broom disease.

ACACIA DECURRENS.

Oidium :—An outbreak of "powdery mildew" disease occurred on young *Acacia* plants grown in the laboratory. The cause of the disease was a species of *Oidium* having spores measuring 34.46×12.17 microns. The spores were produced in great numbers and gave the leaves an appearance as though dusted with flour. The affected leaflets died and fell off.

The occurrence of this disease in the laboratory may be of interest, though it has not been recorded from the field. The plants were obtained locally, and it is thought that the spores were either brought in on the plants or carried in by the wind. This suggests that the fungus occurs in the field but does little harm. *Oidium* diseases, as a rule, become most prevalent during dry weather. It is suggested that a factor which favoured the growth of the fungus in this instance was the fact that the laboratory plants had not been watered by rain; for some months the soil only had been watered.

Cercospora :—Where climatic conditions were favourable for the fungus during the south-west monsoon, *Acacia decurrens* trees were severely attacked by the *Cercospora* leaf disease. In many instances the trees were entirely defoliated.

ALBIZZIA MOLUCCANA.

A disease of *Albizzia moluccana* was reported from the Dickoya district. Field investigations indicated that strong wind is a primary factor in its causation as the disease occurred principally on wind-swept slopes. In advanced stages, definite cankers occur on the stems and the branches die back. Discoloured areas were found in the cortex of stems in an earlier stage of attack, but attempts to isolate fungi from them were unsuccessful. There was no external symptom in these cases to indicate the location of the discoloured area.

ALBIZZIA LOPANTHA.

Armillaria :—A root disease of *Albizzia lopantha* has been found to be due to the attacks of a species of *Armillaria* (probably *A. mellea* or *A. fuscipes*). The most characteristic symptom of this disease is the occurrence of conspicuous longitudinal fissures at the collar. The cortex is permeated with mycelium which appears as white streaks and cords when the bark is cut. The occurrence of characteristic rhizomorphs extending through the soil for some distance from the affected parts forms unmistakable evidence of the true nature of the disease.

In typical attacks of *A. mellea* in other countries, sheets of mycelium occur between the bark and the wood. Diseased specimens of *Albizzia lopantha* and mature tea in Ceylon do not exhibit such sheets. In this respect the Ceylon specimens resemble those of parasitised cacao described from the Gold Coast. The Gold Coast fungus is regarded as a variety of *A. mellea*.

Petch has described a species, *A. fuscipes*, from Ceylon which resembles *A. mellea* in many respects, and which has rhizomorphs, red at first and black later. Fructifications from *Albizzia* and tea have not been found in Ceylon as yet, so it remains to be determined whether the fungus in question is to be regarded as a variety of *A. mellea* or as a distinct species, possibly *A. fuscipes*.

Where *Albizzia lopantha* has been killed by this disease the surrounding tea has not yet been affected. It would appear that *A. lopantha* is much more susceptible to attacks by this fungus than is tea.

Cercospora :—Observations made during the south-west monsoon confirm those made previously, that *Albizzia lopantha* is very susceptible to the *Cercospora* leaf disease.

C. H. GADD,
Mycologist.

REPORT OF THE BIOCHEMIST.

Composition of Shoot and Extract :—Qualitative and quantitative experiments have been carried out on the composition of the tea leaf. These indicate that fresh tea leaf is largely made up of cellulose, protein, tannin, caffeine, ash constituents, resinous and gummy matters which include a small quantity of pectin. A little starch, together with some of its degradation products, is present, but hexose sugar can only be demonstrated in very small amounts. Fresh leaf also contains some volatile constituents which can be obtained by steam distillation of the leaf. This volatile fraction, which has a decided aroma, is acid, and contains small quantities of a ketone, and a reducing substance, but only minute traces of ester could be determined on hydrolysing the distillate with alcoholic potash.

Some of these substances are wholly or partially extracted by water, and, since a cup of tea is essentially an aqueous infusion, considerable attention has been paid to methods of determining the total water-soluble material of the leaf. The method finally adopted for estimating the total water-soluble material of the fresh leaf is to boil 5 gms. of finely powdered dried leaf for 45 minutes with 400 c.c. of distilled water under a reflux

condenser. This is then filtered while hot, washed with hot water and then made up to 500 c.c. on cooling. The amount of dry matter and tannin are determined in the extract.

The amount of water-soluble material obtained varies between 40-50 per cent. of the dry matter for different samples of leaf. The following figures give the analysis of an extract obtained in the manner described.

Composition of Water-soluble Extract.

(Calculated as percentage of the dry matter).

Tannin	..	..	..	27.7
Total nitrogen	..	..	..	2.5
Non-protein nitrogen, chiefly caffeine	..	..	..	1.56
Gummy matters, dextrin, pectin, etc.	..	..	..	6.0
Ash	..	..	..	5.03

Tannin forms the major portion of the water-soluble material, and is undoubtedly one of the chief factors governing the quality of a cup of tea. It must be remembered, however, that the term "tannin" is used to denote a number of substances possessing similar properties found to occur in plant life, and does not refer to any definite chemical substance. The function of tannin in vegetable physiology is as yet uncertain, as these substances vary in different plants, so that what may be true for one is not necessarily true for another. These bodies differ in chemical constitution and reaction, but in general they are uncrystallizable colloidal substances with astringent properties, and impart the characteristic pungency and astringency to a tea infusion.

Little is definitely known concerning the chemical constitution of even the simplest tannin, and most of our knowledge of tea tannin is derived from the work of Nanninga (1) and Deuss (2) on tea in Java. The latter found tea tannin to be a white uncrystallizable powder possessing properties closely resembling those of oak tannins. It readily undergoes oxidation with the formation of brown products which can easily be reduced to the colourless form. When boiled with dilute acid, insoluble red oxidation products, which cannot be changed back to colourless tannin, are formed. These are soluble in solutions containing tannin, and their presence probably accounts for the coppery tinge in infusions of tea and the colour of the fermented leaf. When it is remembered that tea tannin is so unstable, and that the method employed in preparing it from tea consisted of drastic treatments such as extraction with boiling alcohol, it is doubtful whether the product obtained was identical with the tannin present in the tea leaf.

Although tannin is an important factor in a cup of tea, the other constituents must be taken into account, as they form about 40-60% of the dry matter in the extract. However, apart from observations on the tannin, very little is known of the variation in the composition of the water-soluble material or the effect of the other materials on the quality of tea. It is hoped to make a study of this and to correlate any variations with the quality of tea. Although the tea leaf is very rich in protein (30%), as shown by the total nitrogen of the dry matter, very little protein nitrogen is found in the water extract, but the small proportion of these complex bodies found in the extract may affect the thickness of the infusion.

The botanical composition of the shoot plucked varies, as will be seen from the following table which gives the average percentage dry

weights of the various parts of the shoot, together with the maxima and minima found.

Relative Proportions of the Parts of the Shoot, Expressed as Percentage of the Dry Weight of the Shoot.

			Maximum	Average	Minimum
Bud	..	..	16	14	12
First leaf	..	..	31	27	23
Second leaf	..	..	52	42	36
Stalk	..	..	22	17	14

The fresh plucked shoot contains 23-24% dry matter, but there is considerable difference between the dry matter content of the leaves and stalk. The leaves contain 25-26% dry matter, in contrast with 16-17% found in the stalk. The chemical composition of the different parts also varies.

Percentage Composition of Various Parts of the Shoot.

			Water soluble Extract	Tannin	Nitrogen
Bud	..	..	43.0	23.0	5.85
First leaf	..	..	45.0	22.7	5.23
Second leaf	..	..	46.9	18.8	4.43
Stalk	..	..	44.8	15.7	4.10

The younger the leaf the greater the amount of tannin found, since the bud and the first leaf are considerably richer in tannin than the second leaf and stalk. The water-soluble material, however, does not show the same variation, although the nitrogen content shows a graded change from bud to stalk. The variation in the relative proportions of the bud, leaf and stalk in the dried shoot is determined by the rate of growth between successive pluckings, and since the component parts of the shoot vary in their chemical composition this is a factor which determines to a certain degree the quality of the leaf from different plucks.

Withering :—When a shoot is plucked and allowed to wither, it loses moisture, whereby the leaf becomes flaccid and in a suitable condition for rolling. At the same time it appears that the cell wall becomes permeable, so that the juice can be readily squeezed out. When fresh leaf is placed in cold water and a drop of ferric chloride is added, no coloration takes place for several days; hence the cell wall is impermeable to the tannin complex. If withered leaf is treated in this way a greenish coloration is observed in a few minutes, which shows immediate diffusion of the tannin from the leaf.

The rate at which the shoot will lose moisture depends on the temperature, humidity of the surrounding atmosphere, velocity with which the air moves over the leaf, all of which can be controlled, as well as on the internal condition of the shoot itself as regards to its osmotic and stomatal activity. Evaporation does not proceed equally from both surfaces of the leaf, the under surface being most active in this respect, as will be seen from the following figures which were obtained by determining the rate

of loss of moisture of leaves which had been vaselined on their different surfaces.

Treatment		Weight of 100 gms. of fresh leaf.	
		After drying 1 day	After drying 2 days
Untreated leaves	..	47.2	27.8
Upper surface vaselined	..	59.0	35.8
Lower surface vaselined	..	76.6	62.8

The stalk, which contains a higher percentage of moisture than the leaves, is also slower in drying. Loss of moisture during withering should thus be facilitated by turning over the leaf on the tats so as to ensure that both surfaces of the leaf are upwards during a part of the time.

Mann (4) claimed to have found an increase in the water-soluble material of the leaf during the withering process, but later workers have not been able to confirm this. The values found for withered leaf are slightly higher than those obtained with fresh leaf, but the difference is small.

Water-soluble Constituents of Fresh and Withered Leaf.

Fresh	Withered
48.9	49.7
46.2	46.4
43.9	44.4
42.3	43.0

When the means are treated mathematically, it is found that such deviation could be obtained by chance only once in 37 cases, so that the difference found is statistically significant, but practically unimportant.

Several factors contribute to a decrease in the water-soluble constituents of the leaf. Over-withering or excessive drying of the leaf diminishes the water-soluble fraction.

Treatment	% Soluble in Water	
Leaf withered in laboratory	..	47.2
Leaf withered in factory	..	47.2
Leaf withered for 2 days	..	45.3
Leaf withered for 3 days	..	43.7
Leaf completely dried	..	36.9

A sample of withered leaf taken at random from a factory is often visibly heterogeneous, the leaf comprising the sample varying in water content and thus being unequally withered. Such a sample can be easily separated into green withered leaf, red leaf, and hard leaf, and these show considerable variation in moisture content and tannin.

Analysis of Withered Leaf Sample.

	% Moisture	% Soluble Extract	% Tannin
Mixed sample	59.7	45.3	22.1
Green withered leaf	69.6	46.2	23.3
Red leaf	45.3	43.2	21.7
Hard leaf	62.6	43.2	21.9

Although the mixed sample is withered to the proper degree, the figures show that the wither has not taken place uniformly, and that the average degree of withering is misleading as to the real state of the leaf,

some of which is dried out while a portion is not sufficiently withered. It will be seen that the soluble extract and tannin from the red leaf are less than in the case of green leaf, so that part of the sap has become insoluble during the wither. The sap expressed on to the surface of the leaf during the rolling will thus contain less solutes than in the case of well-withered leaf, and full advantage of all the constituents of the tea leaf is not obtained during the fermentation, to the detriment of the tea made, as already pointed out by Deuss. Great care should be taken not to damage the leaf in any way during the plucking, transport to the factory, and while on the tats, since damaged leaf, whether withered or not, will immediately begin the absorption of oxygen which is characteristic of fermenting leaf. Damaged leaf will thus undergo oxidation during withering, and doubtless this accounts for the reddening of the leaf, a process which is accompanied by a diminution in the soluble material during the wither.

Seasonal Variation in the Composition of the Pluck :—A quantitative study of the seasonal changes which occur in the fresh leaf has been carried out during the year on leaf taken periodically from two estates in the Nuwara Eliya district. The amount of extract obtained with boiling water, tannin content of the extract, caffeine and nitrogen have been determined, and the results obtained indicate very clearly a distinct change in the composition of the leaf with time from pruning. This is shown in the irregular increase in the water-soluble constituents and a continuous increase in the tannin up to the sixth or seventh month after the first tipping. The first tipping is very poor in water-soluble material, and contains only 13.6% tannin as compared with 22.6% tannin in the sample taken seven months later. As it is hoped to extend this investigation throughout the pruning cycle, it is premature to make any further remarks until the results can be treated as a whole.

Biochemical :—The sap of the tea leaf is acid in reaction and gives a pH value of 4.3–4.5 as determined colorimetrically. Little difference could be found between the fresh and withered leaf reactions.

Previous workers have demonstrated the presence of an enzyme system consisting of catalase, oxidase, and peroxidase in fresh leaf. The presence of catalase, an enzyme which decomposes hydrogen peroxide into molecular oxygen, is easily demonstrated by crushing a little of the leaf with a dilute solution of hydrogen peroxide, when the peroxide is vigorously decomposed and the oxygen liberated can be measured. The activity of this enzyme, as shown by the amount of oxygen evolved in a certain time, seems to increase slightly during the withering of the leaf. This is specially marked in the case of the stalk, as will be seen from the following data.

**Catalase Activity as shown by the Quantity of Oxygen
Liberated : c.c. of Oxygen Evolved.**

				Fresh	Withered
Bud	..	..	..	30.6	31.0
First leaf	..	..	..	34.8	38.0
Second leaf	..	..	..	38.0	37.5
Stalk	..	..	..	8.6	23.0

Catalase activity rapidly declines during the fermentation process, and is almost negligible four hours after rupturing the leaf cells. The function of this enzyme, which is generally associated with oxydases and peroxidases, is obscure, and the decline in its activity difficult to interpret at present.

When fresh tea leaf or withered leaf is crushed, it readily absorbs oxygen, and becomes copper coloured, while the well-known tea aroma is developed. Fresh leaf dried in the sun or in a desiccator over sulphuric acid will also take up oxygen, change colour, and also produce the characteristic aroma when crushed and moistened, but when the leaf is dried at a high temperature, or steamed for 5 minutes, the power of absorbing oxygen is lost. Further, it has been found that fresh or withered leaf can be dipped in a 1% solution of mercuric chloride without detriment to its power of taking up oxygen, and it is also unaffected by the presence of hydrogen cyanide. Oxygen uptake, which is a characteristic of fermenting tea, is therefore not due to the presence of micro-organisms, as these, if present, would be killed by the mercuric chloride. The rate of oxygen uptake of crushed leaf has been measured, and it has been found that the utilisation of oxygen by the leaf proceeds rapidly for the first 3-4 hours and then slows down; and the relation between the amount of oxygen absorbed and the time taken can be represented by a smooth die-away curve such as is characteristic of enzyme reactions. The following table illustrates the way in which oxygen is taken up by the crushed leaf.

Utilisation of Oxygen by Crushed Tea Leaf.

Time (Mins.)	c.c. Oxygen used up
0	0
15	5.8
30	9.4
45	12.2
60	15.2
75	17.5
173	28.4
210	31.4
240	34.1

When tea leaf is rolled or crushed, certain changes are noted in the extract obtained with boiling water. While the extract changes in colour from greenish yellow to the dark coppery red, the total amount of dry matter which can be extracted diminishes progressively with the time from the first crushing of the leaf, and a substance precipitable by dilute hydrochloric or sulphuric acid, but not by dilute acetic acid, is formed. Very little of this substance is present in an extract of withered leaf, but it increases rapidly, once the leaf is crushed and allowed to ferment. The following table shows the differences in the composition of the extracts obtained from leaf which has been allowed to ferment for different periods of time.

Changes in the Composition of the Extract from Fermenting Leaf.

Sample	Solids in Extract		Tannin in Extract	
	Total	After adding acid	Total	After adding acid
Withered leaf	46.0	45.0	23.6	22.8
Withered leaf rolled for 15 mins. ..	45.8	42.5	22.8	19.4
Withered leaf rolled for 30 mins. ..	46.0	41.6	23.3	19.8
Withered leaf after 2nd roll	41.6	37.9	19.8	16.9
Withered leaf after 3rd roll, 10.20 a.m. ..	41.6	37.6	19.1	15.8
Withered leaf after 3rd roll, 11.15 a.m. ..	39.7	34.4	17.5	12.4
Withered leaf after 3rd roll, 3.15 p.m. ..	36.7	30.6	15.2	10.4
Withered leaf after 3rd roll, next morning ..	32.0	24.8	14.4	8.8

These results illustrate the changes which take place when the leaf is rolled and allowed to ferment. They indicate a short period of induction at the commencement, during which time little change occurs in the total water-soluble material and the total tannin. On the other hand, the material precipitated by dilute acid increases rapidly from the start. After the first thirty minutes there is a continuous decrease in all the constituents estimated. The losses in soluble material and in the substance precipitated by dilute hydrochloric acid are largely accounted for by loss and precipitation of tannin. Since this precipitable material is formed immediately rolling is started it appears to represent a stage in the conversion of soluble to insoluble tannin, the change being shown,

Soluble tannin—tannin precipitated by dilute acid—insoluble tannin.

Deuss (2) in his study of tea tannic acid remarks that when tea tannin is boiled with acid, "tannin red" is formed as a precipitate. The product obtained on acidifying a tea extract is formed immediately, and its properties do not agree with those of "tannin red." It appears to be more closely related to the brown oxidation products of tannin, and probably determines to a certain extent the nature of the made tea. The proportion of this substance present in the extract increases considerably during the rolling and fermenting, owing to the simultaneous decrease in the total soluble constituents, and hence it will be realised why estimations of total tannin in tea have given such confusing results in the past, since the characteristic property of a tea will be affected by the relative distribution of the different substances which have been estimated as tannin.

The rate of loss of soluble material during the rolling and fermenting of withered leaf follows closely the uptake of oxygen. Since the loss of soluble material is largely accounted for by the loss of tannin, it is reasonable to suppose that the decrease in tannin is connected with the uptake of oxygen, and that the changes observed are the result of chemical reactions proceeding at definite rates. One of the reactions which proceeds during the manufacture of tea is, therefore, the result of an oxidation which is not due to the activity of any micro-organisms present. It must not be assumed from this that the presence of micro-organisms is entirely unnecessary for the process of tea manufacture, as the foregoing only refers to one definite change, namely the oxidation which can proceed under sterile conditions.

This preliminary survey of the problems of tea manufacture indicates promising lines of research which should throw light on the biochemical changes which take place in the tea leaf from the time it is plucked until it is made into dried tea. As the changes produced are spontaneous, they should be governed by the well-known laws of chemical reaction. The relation of these changes to time is being studied, and a more detailed investigation of the conditions which determine the progress of the fermentation is being carried out.

Visits :—The following estates have been visited during the year in order to study methods of manufacture.

Craig, Pita Ratmalie, Glen Alpin, Spring Valley, Delmar, St. Leonards, Gonapitiya, Bramley, St. Clair, Drayton, Hantane, and Hunasgeriya Group.

D. I. EVANS,
Biochemist.

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REPORT OF THE ENTOMOLOGIST.

Advisory :—501 letters were received, and 455 were sent out. 186 consignments of insects or damaged plants were received for report. These included 154 in connection with tea, 10 *Albizzia*, 4 *Gliricidia*, 2 each *Acrocarpus*, *Dadap* and *Tephrosia*, and one each *Acacia*, *Derris robusta*, *Grevillea* and *Indigofera*.

Touring :—Forty-six visits were paid to estates, for advisory and experimental purposes, including two special tours in Haputale and Maskeliya.

Agricultural Conference :—A paper, "Mites as Pests of the Tea Plant," was read at the Conference held at Peradeniya in March.

T E A .

Tea Tortrix (*Homona coffearia* Nietn.) :—In February of this year printed circulars, requesting particulars of the infestation of estates and methods of control in practice, were issued to all tea estates of over 10 acres in the following districts :—Alagalla, Ambegamuwa, Badulla, Balangoda, Dickoya, Dimbula, Dolosbage, Hantane, Haputale, Hewaheta, Hunasgiriya, Kadugannawa, Kalutara, Kegalla, Kelani Valley, Kotmale, Madulsima, Maskeliya, New Galway, Nilambe, Passara, Pundaluoya, Pussellawa, Rakwana, Ramboda, Ratnapura, Walapane. To 846 circulars sent out, 561 replies were received.

Eventually, it was decided to recommend to Government that Tea Tortrix be declared a pest under the Plant Protection Ordinance, with the regulation that egg-masses be collected on every tea estate. This proposal was adopted, and Tea Tortrix was declared a pest on November 11th. As was expected, a good deal of opposition to this has arisen in some quarters. But the fact remains that the recommendation of some general measure for dealing with Tortrix was demanded, and the only one that it has been possible to advocate at the present time is that of egg-mass collecting. If this method proves a success ultimately, it will afford the solution of the Tortrix problem.

In this connection it is an interesting and significant fact that egg-mass collecting is recommended in Formosa as the most effective method of dealing with Tea Tortrix.

According to report, unusually severe attacks have occurred in some parts of Maskeliya this year.

While the above measure has been put into action, the Entomologist has taken up the question of utilising the parasites of Tea Tortrix as a means of control. As stated previously, those parasites that attack the

egg-mass are the most likely to give the best results. As a first step, therefore, in the propagation of these parasites, six days were spent in the Tortrix zone in an attempt to obtain egg-parasites.

A large number of egg-masses were obtained from Maskeliya estates and examined for traces of parasitism. Contrary to expectation, it was found, from an examination of 1,600 egg-masses, that about 14% of the masses showed the presence of parasites. In addition, although the degree of infestation of individual egg-masses varied considerably, a number showed practically 100% parasitism.

Attempts are now being made to propagate these parasites, and suitable cages for this purpose have been designed and constructed.

One of the chief difficulties encountered in the breeding of the egg-parasites is the necessity for a constant supply of egg-masses. These are not always available on demand, and in addition, the declaration of Tea Tortrix as a pest precludes the forwarding of egg-masses from infested estates. It has been necessary, therefore, to consider the use of a more convenient means of breeding the parasites, replacing the continued use of egg-masses.

It has been found in America, that egg-parasites of the genus *Trichogramma* may be readily propagated on the eggs of the Angoumois Grain Moth (*Sitotroga cerealella*), a cosmopolitan pest of various grains. Since the egg-parasites of Tortrix belong to the same genus, or are very closely allied to it, it was decided that an attempt should be made to utilise the eggs of *Sitotroga* in place of the egg-masses of Tortrix. With this intention, a quantity of Indian Corn infested by the Grain Moth has been obtained from local sources, and experiments in the breeding of the moth have been commenced. Up to date there appears to be every likelihood that constant propagation of the moth may be carried out, provided that the necessary temperature be maintained. It appears, however, that the normal temperature of Nuwara Eliya is too low for the satisfactory breeding of *Sitotroga*. Attempts to induce the parasites to attack the eggs of *Sitotroga* have met with some success, and from these trials it is evident that natural parasitism will occur. The chief difficulty with which to contend is the requirement of a large and constant supply of the moth's eggs, which are not at present available in sufficient quantity to meet the demand of the parasites.

I am indebted to the Proefstation voor Thee, Buitenzorg, for the information that *Homona menciiana* Walk., a pest of tea in Java, India and Formosa, is identical with *Homona coffearia* Nietn.

Shot-hole Borer (*Xyleborus fornicatus* Eichh.):—There appears to be little change in the situation as far as attacks on tea bushes are concerned, but Shot-hole Borer has this year assumed a new rôle as a pest of tea seed. Several reports have been received that consignments of seed have arrived from other estates containing a certain proportion of seeds showing infestation by the borer. In the case under observation from $\frac{1}{2}\%$ to 1% were affected. The Government Entomologist has informed me that the beetle also bores through the seed capsules into the green seed still on the bush. In the case of mature seed I have found that about 50% of the borings pass either through or very close to the radicle, so that germination will probably be affected in many cases. It is not, however, the actual loss

in seed that is the serious feature of this developing tendency of the borer, but the danger of infecting estates hitherto free from this pest, through the medium of the seed.

I take this opportunity of emphasising the importance of examining carefully all seed either sent out or received from estates for the possible presence of Shot-hole Borer ; this is readily determined by the small round hole so characteristic of this insect. All seeds found to be attacked should be either destroyed or treated as advised. If a sufficiently large number are infected to render treatment worth while, fumigation by means of carbon bisulphide would probably prove effective ; this method has not yet, however, been tested out.

Tea seeds have also been received for report showing the attack of a smaller species of borer which, I am informed by the Government Entomologist, has been identified as a species of *Coccotrypes*, closely resembling, but not identical with, *C. pygmaeus* Eichh.

In seeds showing traces of decay there have frequently been found various fly maggots. The investigation of one sample of seed that had failed to germinate revealed the presence of these maggots in many of the seeds, and eggs of the fly were even found on the surface of one seed. But since all infested seeds were found to be decayed, it has been assumed that the maggot's attack is entirely secondary and that the original rotting of the seed was due probably to excessive dampness in the seed bed. It is unlikely that the maggots attack the healthy seed under natural conditions, although in the laboratory such seed was certainly penetrated by some of the maggots.

Several new names have been added to the list of estates infested by Shot-hole Borer.

Tea Mites :—These pests figure prominently in the applications for advice received from various estates.

Scarlet Mite (*Brevipalpus obovatus* Donn.) again showed itself to be a pest of considerable importance, by reason of the great damage that it frequently causes in tea nurseries. On one estate Scarlet Mite was chiefly responsible for the loss of nearly 100,000 plants.

Experiments in spraying and dusting with various chemicals for the control of Scarlet Mite were carried out in the earlier parts of the year, but these were interfered with considerably by the unusually prolonged rainfall experienced during those months. It is intended to repeat these experiments in greater detail next year, and therefore it is not thought advisable to do more here than mention the bare outline of the results so far obtained.

As regards Scarlet Mite in the field, dusting with sulphur or any other chemical substance is not recommended, since the mites, which live on the under side of the leaves, cannot be adequately treated by this method, and dusting is in itself a wasteful and therefore expensive process. I have found that about 1 cwt. of flowers of sulphur is required to treat properly one acre of tea. Spraying commends itself to a greater extent, but even here it is felt that there are few occasions on which the necessary expense involved in the outlay for machines (for comparatively few estates possess these accessories) and the labour required, would justify treat-

ment over an extended area. But in chronic cases, such as that quoted in the Annual Report for 1926, it might pay to treat the bushes thoroughly, and rid them completely of the pest.

From test and observation it is believed that spray mixtures containing sulphur would be inadmissible, owing to the almost certain tainting of the manufactured tea. A certain degree of success has been obtained with mixtures containing kerosene and flour, with or without the addition of soft soap. Here the kerosene, being volatile, soon evaporates, leaving nothing behind that might be injurious to the flavour of the tea. It is believed that these mixtures could safely be employed, but further experiment is required before definite recommendations are issued.

For Scarlet Mite on seedlings in tea nurseries, on supplies or in clearings, sulphur is advocated. Here, where the danger of tainting need not be considered, a sulphur spray may be employed with impunity. Sulphur and soft soap are suggested for this purpose.

Tainting Tests :—The question of sulphur tainting in connection with mite control has led to experiments with different insecticides, with a view to eliminating those that produce definite tainting in the manufactured tea. The substances under experiment so far are sulphur-soap mixture, kerosene-flour mixture and sodium silicofluoride.

Yellow Mite (*Tarsonemus translucens* Green):—This species was reported more frequently than any other. Although it certainly does not seem to obtain such a hold on the tea bush as does Scarlet Mite, it is potentially a pest of some consequence, as illustrated by an attack reported from Matale. In this case the bushes over ten acres, as the result of the attack, dropped the leaves from their younger shoots, so that they had (to quote the Superintendent of the estate concerned) “the appearance of having been systematically stripped.” This would obviously be a serious state of affairs if the attack were prolonged. But fortunately, Yellow Mite appears to be very susceptible to showers of rain. This is undoubtedly due, to a large extent, to the fact that the mites live only on the young shoots and thus miss the protection of the older leaves.

Regarding another attack covering about 15 acres it was reported that “a considerable amount of damage to flush has been noticed, the attacked bushes giving hardly any leaf at all.”

Nettle Grubs (Limacodidae):—Nettle Grubs have been reported this year from the Passara, Badulla, Matale and Galle districts. An estate in the last-named district, visited this year by Nettle Grub, lost in 1926, I am informed, as much as 100 lbs. per acre of made tea in a certain field, and the work of control cost over Rs. 4,000.

To Mr. Aubrey Clarke, of El Teb Estate, I am indebted for a résumé of the incidence of this pest in the Passara district. Attacks this year have been more widespread, but briefer in duration. Nettle Grub is apparently developing the tendency to attack tea coming in from pruning, whereas formerly only fields in full bearing were visited. Fortunately, unlike Tea Tortrix, this pest does not normally attack the flush, but prefers the older leaves. Picking off and burning the infected leaves has proved successful in dealing with small areas.

Red Borer (*Zeuzera coffeae* Nietn.):—A good many reports of this insect, which is also known as the Coffee Borer, have been received. Most of the attacks seem to have occurred in clearings. In one instance, an unusual case, several hundred plants were hollowed out in a two-year-old clearing. Many of the plants were said to have come away again from the roots.

Bark-eating Borers (Arbelidae):—These pests, which commonly attack Albizzia, seldom turn their attention to tea, and do little damage, since the reports received referred to single bushes only. *Arbela quadrinotata* Wlk. was recorded, and also a larger caterpillar which may be that of the Hepialid moth *Phassus purpurascens* Mo., received from Haputale. The boring of the latter resembled that of Arbela, and the same sheet of webbed-up frass was formed on the bark outside the boring, to act as a protection to the caterpillar while feeding.

Red Slug (*Heterusia cingala* Mo.):—Several reports have been sent in from various parts of the tea area. Red Slug breaks out at times over considerable areas, an attack over 35 acres being recorded in one instance. As with Nettle Grub, this caterpillar apparently prefers the older leaves, and since it is not so persistent as Nettle Grub, it can be dealt with before much loss to the bushes has been sustained. Picking and burning the infested foliage appears to be a satisfactory method of control.

On one estate attacked by Red Slug, the superintendent stated that control was assisted considerably by crows, which swarmed over the infested area. The Tachinid parasite, *Exorista heterusiae*, is apparently instrumental in the natural control of this pest. When caterpillars of *Heterusia* are bred out in the laboratory, some of these parasites almost invariably appear.

Bag Worms (*Psychidae*):—These are common pests of tea, the most frequently occurring species being *Psyche albipes* Mo. *Psyche vitrea* Hmps. has also been reported.

A species of so-called Faggot Worm (a Bag Worm that constructs its case of small twigs) was described as causing considerable injury to seedlings in a clearing planted seed-at-stake last year. This species is probably *Clania crameri* Westw.

Clania variegata Snell., a large species whose case is composed mainly of two leaves opposed to each other lengthwise, has recently been reported attacking a small patch of bushes in the Badulla district. This occurrence is of note since the insects were stated to have stripped the foliage completely.

Chalia doubledayi Westw., defoliating Albizzia on one estate, spread to the tea, and some difficulty was experienced in controlling it. The caterpillars were described as attacking the leaves and bark of the tea.

Small Tussock Moth (*Notolophus posticus* Wlk.):—The young caterpillars of this moth are frequently encountered feeding gregariously on bushes here and there in the field. Supplies have been observed to be almost completely defoliated.

Albizzia Caterpillar (*Terias silhetana* Wallace):—When severe attacks of *Terias* occur on Albizzia and the insects breed abundantly, it has been observed, in recent years, that the caterpillars drop down on to the tea

bushes ; they have even been seen crawling down the trunks of the trees. A certain amount of damage is done to the foliage of the bushes, but it appears that the deliberate migration of the caterpillars is for the purpose of pupating beneath the leaves of the tea. Large numbers of pupae are found in this position. A possible explanation is that the caterpillars, having stripped the *Albizia* foliage, require further leaf space for pupation, and hence are forced to turn to the abundant foliage of the tea bushes.

Since the commencement of this report, information has been received of further injury to tea beneath *Acrocarpus*. One bush is stated to have been completely stripped. From this it seems that *Terias* is progressing in its adaptation to tea. If this pest continues to adapt itself at the present rate, it may become a menace to the tea. It is requested, therefore, that outbreaks be carefully noted, and that further attacks on tea be reported without delay.

Other leaf-eating caterpillars that have been reported on tea are *Boarmia acaciaria* (Geometridae), *Adoxophyes privata*, *Cacaecia epicurta* and *Gracilaria theivora* (Tortricidae) ; all are minor pests.

Cutworm (*Agrotis ypsilon* Rott.):—This insect, so well-known as a pest of nursery plants, has also been reported this year as causing serious losses in clearings. Young plants from seed-at-stake in a clearing on one estate suffered a 50% loss; in this case the cleared area was originally patana land, and it is probable that the insects came from the patana soil ; but an examination of similar land adjoining the clearing yielded a negative result. Another report stated that a 15-acre clearing, also on patana soil, had suffered seriously, involving a loss of four or five thousand seedlings. 1,600 cutworms were collected in four days.

White Grub (*Anomala* spp., etc.):—It has been observed that Cutworm on clearings or in nurseries is sometimes accompanied by White Grub. The latter attacks especially young plants in the field, which it often kills by destroying the entire root system.

Crickets (*Gryllidae*):—Recently, also, the presence of crickets has been noticed in connection with outbreaks of Cutworm. In the first of the two reports of Cutworm damage quoted above, a number of specimens of a small black cricket were found in the clearing. On examination it was seen that a number of the young plants were eaten off at a height of two or three inches from the ground, and in some cases the leaves were completely nibbled away. This type of injury I have begun to associate with crickets, for Cutworm, normally, merely cuts through the plant at soil level and does not feed on the leaves. The same kind of damage has been observed in nursery plants. Any information from first-hand observations on the feeding of crickets and cutworms will be gratefully received.

Grasshoppers (*Acridiidae*):—Several species were found attacking basket plants in a nursery in Haputale. The insects were not abundant, but a good many plants were killed by having their tops nibbled off as they appeared above the soil. A poison bait such as that recommended for Cutworm might be tried for the control of these pests.

Spotted Locust (*Aularches miliaris* F.):—An attack of hoppers over two or three acres was reported from the Madulkelle district. The chief



TEA NURSERY ATTACKED BY EELWORMS.

damage was inflicted on the interplanted dadaps, but the tea evidently suffered also to some extent.

Weevils (*Astycus* spp.):—An outbreak of these beetles was investigated in Haputale. Young tea stumps in an old jungle clearing of 15 acres were attacked by the weevils. Hand collection by podians was promptly applied and the plants escaped much damage; but some were almost completely stripped of foliage. Two species of the insects were found together on the plants, viz., *Astycus apicatus* Mshll., and *Astycus immunis* Walk.

Scale Insects (*Coccidae*):—A single bush was found covered with a species of *Ceroplastes*. This occurrence is noted owing to the interesting fact that 90% of the specimens sent in for identification were parasitised by an unusually beautiful Braconid wasp, not yet identified.

Specimens of *Pseudococcus lilacinus* Kkll. were found on the roots of mature bushes, but appeared to be doing little damage.

Tea Aphis (*Toxoptera aurantii* Boy.):—Specimens are frequently sent in with the complaint that they are causing injury to shoots on recently pruned tea. This is commonly the case, the insects appearing in numbers on the young shoots, and producing considerable curling and distortion of the leaves, and sometimes complete atrophy of the buds. The attacks, however, seldom appear to continue for long, and rain quickly washes the insects away. In the case of persistent attacks spraying with kerosene emulsion is advised; with 25 gallons of water use 1 gallon of kerosene and $\frac{1}{4}$ lb. of soft soap.

Plant-sucking Bugs (Capsidae, etc.):—Consignments of tea leaves have often been received showing a crumpled or distorted appearance, with discoloration spreading out from a number of spots and punctures in the leaf surface. This injury is caused by various species of plant-sucking bugs. The nature of the damage varies somewhat in different cases, but the spotted appearance often resembles an attack of the fungus *Cercospora* Theae; a distinction readily recognisable lies in the fact that the spots produced by the insects usually possess a transparent centre, where the cell contents have been sucked out, and the leaf tissue ultimately dried to a thin film.

It is difficult to discover what species of bugs are actually responsible for the injury, for although such damage occurs quite commonly, it is rarely that the insects are seen feeding on the plants. It is possible that they feed largely at night. Certain species of Capsidae, such as *Callitricatides rama* Kirby, attack the bushes; various Fulgoridae commonly found on tea are also probable aggressors.

Eelworm (*Heterodera radicola* Greef):—Observations have been made on the distribution of this serious pest of tea nurseries. Most of the occurrences reported have been in the Badulla district. A loss of some 230,000 plants in a Passara nursery was due mainly to the activity of Eelworm.

Other pests reported or observed during 1927 include Termites (*Calotermes* spp.), Green Bug (*Coccus viridis*), Brown Bug (*Saissetia hemisphaerica*), Leaf Miner (*Oscinis theae*).

ACROCARPUS.

Albizzia Caterpillar (*Terias silhetana* Wallace):—The caterpillar of this common butterfly has become an important pest of *Acrocarpus* in some districts. It has been known to strip the trees practically bare of foliage over a considerable area.

The eggs are white and oval, pointed at the upper end, and are laid in an upright position, in clusters on the under surface of the small red leaves of young shoots. An outbreak on one estate was successfully controlled by fortnightly treatment consisting of the removal of all branches bearing the chrysalides, and of shoots showing the presence of the butterfly's eggs.

A boring caterpillar has also been reported as doing considerable damage to *Acrocarpus*.

ALBIZZIA.

Albizzia Caterpillar (*Terias silhetana*, etc.):—The usual outbreaks were reported, including a serious case where young *Albizzias* over 400 acres were almost completely defoliated. This occurrence has brought up a point of importance in dealing with this pest. It has been found that in some districts *Albizzias* cannot be lopped satisfactorily, as the cut branches tend to die back. In the instance referred to, none of the lopped branches survived, and the young growth that came away from the remaining branches was destroyed by the caterpillars as it appeared. Thus the method of lopping usually advised in controlling such pests in shade trees cannot be applied in some districts. If the attacks of *Terias* were prolonged and continually repeated, it might be advisable in certain cases to cut out the *Albizzias* and replace them with some other green manure.

An interesting observation made during the outbreak quoted was that a certain number of older *Albizzias* which had been allowed to run up to 40 or 50 ft. were practically undamaged, although standing amidst younger trees badly attacked. The probable explanation of this is that *Terias*, which is a low flier, apparently prefers to lay its eggs at a height of 10-15 ft. from the ground. The eggs are laid, as on *Acrocarpus*, on the under sides of the terminal leaves of young shoots.

An enemy of *Terias* occurs in the form of a red ant (about half the size of the common red ant), which on one estate was present in large numbers on many of the *Albizzia* trees, and formed large nests underground. The ants were frequently observed attacking the caterpillars, and also the butterflies, whose wings, torn off, might be seen lying beneath the tea bushes.

BOGA MEDELOA (*Tephrosia candida* DC.)

Xyleborus discolor Bldf.:—The first record of this species, a shot-hole boring beetle, somewhat smaller than Shot-hole Borer, and distinguished from the latter by the fore part of the body being of a reddish colour (*i.e.*, elytra black and prothorax ferruginous). This beetle was found attacking two-year-old plants, but apparently avoiding the younger ones. The galleries of *X. discolor* are usually very short and do not appear to ring the stems, as with *X. fornicatus*. In many of the galleries were found the maggots of certain flies, which although not so far recorded in Ceylon from

the galleries of *X. discolor*, have been found in those of Shot-hole Borer. *Xyleborus discolor* has been recorded previously on *Albizzia*, *Hevea*, *Lonicera caprifolia* and *Cassia multijuga*: for this information I am indebted to the Department of Agriculture.

Mealy-bug (*Pseudococcus* spp.):—Boga plants have been seen turned quite black with sooty mould following Mealy-bug attack, and some of the plants have been killed.

Ceroplastodes cajani Mask.:—This scale insect was sent in on one occasion densely infesting Boga stems, as a result of which a number of plants died.

CROTALARIA SALTIANA Andr.

Pod-boring Caterpillars:—The following species of caterpillars have been found boring into the pods of *Crotalaria*, and doing much damage to the seeds.

A brown Noctuid moth, the caterpillar of which is black, with white markings on the body and a red head. When young, the caterpillar lives inside the pod, but as it grows older and too large for this, it makes a large hole at one end of the pod, into which it enters, and remains thus, feeding on the seeds with the hinder part of its body protruding from the pod.

The dark green larva of a Pyralid moth, which when older acquires a crimson tinge on the under side of the body, appears to be the same as a species commonly found feeding in Boga pods. The egg of the moth is rose-red in colour, oval, the surface dotted with minute papillae; length 0.60-0.65 mm. It is laid on the outside of the pod. A Braconid parasite was found, which forms small, white, elongate cocoons inside the pod.

A Lycaenid butterfly, which appears to be the common blue species that attacks various Leguminosae, including Boga and lupin, lays its eggs on the *Crotalaria* pod. The pale green egg is 0.56 mm. in diameter, round, flattish and ornamented with white papillae and a white network pattern.

Tea Tortrix (*Homona coffearia* Nietn.) was seen to have done much damage to *Crotalaria* plants in Haputale.

DADAP (*Erythrina lithosperma* Bl.)

Spotted Locust (*Aularches miliaris* F.):—Hoppers were reported to be causing considerable defoliation of trees in the Madulkelle district, and also doing a certain amount of damage to the tea.

Grey Dadap Caterpillar (*Suana concolor* Wlk.):—Reported occasionally on Dadaps. The large white cocoons have been seen on several occasions attached to the twigs of tea bushes, but no damage to the tea has been observed.

Other pests of Dadap recorded are the Dadap Borer (*Agathodes ostentalis* Hubn.) and a small green weevil, *Astycus immunis* Walk. var. *bilineatus* Mshll.

DERRIS ROBUSTA Benth.

Shot-hole Borer (*Xyleborus fornicatus* Eichh.):—Attacking young plants of *Derris robusta* about ten months in the field. The beetle evidently spread from the tea, which was already infected.

GLIRICIDIA MACULATA H.B.&K.

Mealy-bug (*Pseudococcus* spp.):—The species of mealy-bug already recorded are *Pseudococcus citri* Risso and *P. virgatus* Ckll., but others may occur.

These insects sometimes attack considerable areas of interplanted Gliricidias, so that most of the trees are covered with sooty mould, and the tea bushes beneath also receive a covering of mould. No report has yet been made of trees being killed out by this pest, but it evidently affects the growth appreciably by retarding the formation of new shoots.

The susceptibility of Gliricidia to mealy-bug should prove an important factor in the choice of this green manure for planting through tea. Gliricidia is capable of growing satisfactorily at various elevations, but it has become apparent that certain districts are favourable to the development of mealy-bug. The Badulla district is a case in point; nearly all the outbreaks reported so far have been in this region. It is advised, therefore, that when contemplating planting Gliricidias, the previous history of these trees in the district should be considered, and if the trees are markedly susceptible to mealy-bug attack, it would be preferable to substitute some other green manure for Gliricidia.

Aphis:—A species of aphis has been found to attack the young shoots, resulting in a wilted appearance of the shoots, but little subsequent injury.

Green Bug (*Coccus viridis*) has also been reported on Gliricidia.

INDIGOFERA ENDECAPHYLLA Jacq.

Indigofera Caterpillar (*Dichomeris ianthes* Meyr.):—This appears to be the only pest of any importance. The plants are frequently completely defoliated by the caterpillar, which, in the manner of many Tortricidae, webs itself up in the leaves and also pupates in this position. Spraying with Paris Green is recommended, at the rate of 1 oz. Paris Green to 10 gallons of water.

S. STUART LIGHT,
Entomologist.

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 Nowell, W.
 O'Brien, T. E. H.
 O'Connell, H. G.
 Ocfemia, G. O.
 Ocfemia, G. O.
 Ocfemia, G. O.
 Okakura-Kakuzo
 Palladin, V. I.
 Park, M.
 Park, M.
 Petch, T.
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TEA RESEARCH INSTITUTE OF CEYLON.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1927.

EXPENDITURE.	Rs.	Cts.	INCOME.	Rs.	Cts.
To Expenditure as per attached Statement	..	103,586	By Tea Cess Collections	..	227,257
„ Balance, being excess of Income over Expenditure	..	128,149	„ Interest	..	4,478
					39
	Rs.	231,736		Rs.	231,736
		17			17

BALANCE SHEET AS AT 31st DECEMBER, 1927.

LIABILITIES.	Rs.	Cts.	ASSETS.	Rs.	Cts.
Tea Research Funds Account as at 31st December, 1927	..	278,591	Mercantile Bank of India, Colombo	..	75,000
		14	Do do Kandy	..	150,000
			National Bank of India, Colombo	..	49,562
			Do do Nuwara Eliya	..	603
			In hand	..	34
			Stamps in hand	..	11
			Ceylon Association in London	..	78
	Rs.	278,591		..	3,378
		14		Rs.	278,591
					14

Audited and found correct.

(Signed) FORD, RHODES, THORNTON & Co.,
Chartered Accountants.

Colombo, 3rd March, 1928.

TEA RESEARCH INSTITUTE OF CEYLON.

EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1927

Administration of the Board :—			Rs.	c.	Rs.	cts.
Planters' Association of Ceylon	..	..	2,400	00		
Secretary	..	..	2,400	00		
Travelling Expenses of the Board	..	..	707	04		
Postages	..	..	124	23		
Stationery	..	..	518	24		
Advertising	..	..	247	00		
Telephone Trunk Calls	..	..	26	43		
Telegraphic Address, &c.	..	..	24	00		
Telegrams, Cables, Commission and Cheque Book	..	..	335	76		
Printing	..	..	276	60		
Legal Charges	..	..	660	16		
Auditors' Fee and Expenses	..	..	295	57	8,015	03
Personal Emoluments of Scientific Staff :—						
Director	..	..	22,500	00		
Entomologist	..	..	9,374	04		
Mycologist	..	..	14,100	00		
Biochemist	..	..	10,860	00		
Agricultural Chemist	..	..	2,731	51		
House Allowances	..	..	8,809	50	68,375	05
Laboratory Office Expenses						
Clerk	..	..	720	00		
Peon	..	..	282	10		
Stationery	..	..	344	91		
Postages	..	..	146	06		
Telephone Rent	..	..	180	00	1,673	07
Laboratory Expenses :—						
Cooly	..	..	262	72		
Rent and Taxes	..	..	2,301	60		
Insurance	..	..	43	75		
Equipment	..	..	6,411	07		
Furniture and Alterations	..	..	4,420	65		
Library	..	..	930	19		
Publications	..	..	293	98	14,663	96
Field and Factory Experiments					354	20
Travelling Expenses of Staff :—						
Officers' Expenses	..	..	1,277	29		
Insurance of Car	..	..	189	90		
Taxes	..	..	40	00		
Driver's Wages	..	..	1,020	00		
Driver's Batta	..	..	305	00		
Running Expenses	..	..	1,473	99	4,306	18
Contingencies :—						
Passages	..	..	2,521	84		
Incidentals	..	..	471	02		
Visiting Fees and Advertising Charges <i>re</i>						
Purchase of an Estate	..	..	1,653	00		
Provident Fund	..	..	1,553	48	6,199	34
					Rs. 103,586	83

